METHANE MITIGATION STRATEGIES FOR DAIRY HERDS

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INTRODUCTION

The U.S. dairy industry has committed to decreasing methane emissions by 25% by 2020 (Tricarico, 2014). This is a value for the total dairy industry from feed production to consumption by consumers. In terms of the total dairy supply chain, milk production accounts for about 51.5% of the methane emissions while on-farm feed production accounts for 20.3%. Thus, the primary area for lowering dairy industry methane emissions is nutritional and management factors related to milk production. The U.S. EPA publishes a report on greenhouse gas (GHG) emissions that provides data by individual gases and the contributions by various sectors (U.S. EPA, 2016). Key points from this most recent report are

- Total U.S. GHG emissions were 6,870 MMT of CO_2 equivalents in 2014 compared with 6,397 in 1990.
- Total methane emissions were 730.8 MMT of CO_2 equivalents in 2014 compared with 773.9 in 1990. Methane emissions were 10.6% of the total GHG emissions.
- Enteric methane emissions were 164.3 MMT of CO_2 in 2014 which is similar to the 1990 value. Enteric methane emissions are 22.5% of the total methane emissions.
- Methane emissions from dairy cattle in 2014 were 41.9 MMT of CO_2 equivalents. This is 5.7% of the total methane emissions and 0.6% of the total U.S. GHG emissions.
- Methane emissions from beef cattle were 116.7 MMT of CO_2 equivalents in 2014. A large portion of this is the enteric methane emissions from cow-calf operations.

MEASUREMEMT

There are 2 main ways to express methane emissions from dairy cattle. One is as grams/lb. of milk produced while the other is actual grams (or liters). Table 1 contains methane emissions at varying levels of milk production using these measures. A ration with 53% forage and 47% concentrate (DM basis) was used. The forage mix 56% corn silage and 44% alfalfa silage. Ration nutrient values were 17.6% CP, 31.5% NDF, 26% starch and 4.7% fat. As milk production increases, the methane emissions per pound of milk produced decrease. However, total daily methane emissions (g/day) increase with higher levels of milk production. This is logical since more feed is being consumed and processed in the rumen. It is suggested that methane emissions be reported using both methods in future papers.

Table 1. Methane Emissions for Dairy Cattle at Varying Milk Production Levels[a]

Milk, lbs./day	**Dry Matter Intake, lbs./day**	**Methane Emissions, g/day**	**Methane Emissions, g/lb. milk**
40	41	373	9.32
60	47	409	6.82
80	52.5	439	5.49
100	61	482	4.82
120	67	509	4.24

[a] Calculated using the CNCPS version 6.5 model (Van Amburgh et. al., 2015)

DISTRIBUTION OF METHANE EMISSIONS IN DAIRY HERDS

Herd structure will impact both total methane emissions and the opportunity to adjust practices to decrease methane emissions. Factors such as the number of milk cows, number of dry cows and the number of replacement heifers are key factors that influence this. Some preliminary work has been done using herds with 150 and 1,500 total cows. In these herds dry cows were about 13% of the total cows while replacement heifers were about 85-87% of the total cow numbers. Methane emissions from the dry cows represented about 7 -7.5% of the total herd emissions. Replacement heifers accounted for 18.5- 20.7% of the total herd emissions. Additional work needs to be done in other herds to better quantify these values and better estimate the variability that exists. The result is that the net effects of adjusting milking cow rations to lower methane emissions will be impacted and reduced at the herd level by the number of dry cows and replacement heifers.

COMMERCIAL DAIRY HERD RATIONS

As part of a larger study, a database of commercial dairy herd rations is being developed. All rations are run through the CNCPS 6.5 model to estimate methane emissions and nitrogen and phosphorus excretion (Van Amburgh et. al., 2015). The initial database contains 199 rations. The average target milk was 83.7 lbs. per day with range of 50 to 128 lbs. Average dry matter intake was 51.4 lbs. with a range of 35.2 to 69.8 lbs. An initial evaluation was to examine correlation coefficients between ration factors and daily methane emissions (g/day). Dry matter intake (DMI) had a correlation coefficient of +0.795 with daily methane production (g/day). The correlation of DMI and methane emissions (g/lb. milk) was -0.65. A second evaluation was done with a constant DMI for all rations to examine the potential relationships of nutrients with daily methane emissions. The correlation coefficients in this evaluation were 0.1, 0.636, -0.27 and 0.23 for CP, NDF, starch and fat. This indicates that higher NDF rations tend to increase methane emissions while higher starch rations tend to decrease methane emissions. Additional herds are being added to increase the number of diversity of the rations used. An additional dataset using rations from peer reviewed journal papers will also be developed.

REVIEW PAPERS

Some excellent review papers have been published regarding options for methane reduction in dairy herds (Hristov, 2013a, and 2013b and Knapp et.al. 2014). The papers by Histov used a ranking system of low, medium and high to rank options to lower GHG emissions. Low was a <10% reduction, medium was 10-30% and high was >30% in terms of mitigation potential. The options listed were:

- Low, rBST, ionophores, plant bioactive compounds, grazing management, genetic selection, improved animal health and reduced animal mortality.
- Low to medium – Improved forage quality, feeding grain, precision feeding.
- Medium – Dietary lipids.
- High – Increased productivity.

The paper by Knapp et.al. (2014) listed the following management options and the maximum potential GHG emission reduction associated with each:

- Genetic selection = 18%.
- Feeding and nutrition = 15%.
- Rumen modifiers = 5%.
- Other management approaches = 18%.
- All approaches combined = 30%.

HERD MANAGEMENT OPTIONS

There are a number of herd management options that can assist in reducing GHG emissions from dairy herds. These include:

1. Increased productivity and efficiency –
   - A one standard deviation increase in feed efficiency would lower CO_2 equivalent emissions by 6.5% (Bell et.al. 2011). Bauman and Capper (2010) reported that the use of rBST could lower methane emissions by 8.3% compared to not using rBST. This decrease is a combination of more milk per cow and fewer cows to produce a set quantity of milk.
2. Calf and heifer management –
   - Dairy replacement heifers can account for up to 27% of the total CH4 emissions in a dairy herd (Garnsworthy, 2004). Decreasing the age at 1st calving lowers the number of heifers needed to maintain current herd size and would provide some decrease in GHG emissions.
3. Reproduction –
   - Garnsworthy (2004) indicated that if herds in the United Kingdom could improve herd fertility levels to those of 1995 that methane emissions could be lowered by 10-11%.
4. Forage type and quality –
   - A 5% decrease in methane emissions could result from improving total tract NDF digestibility (Knapp et.al. 2014). Methane emissions when C4 grasses were fed had 17% higher methane emissions than when C3 forages were fed (Archimede et.al. 2011). A number of other reports indicate lower methane emissions on higher corn silage diets.

5. Herd grouping strategy
    - o. A recent paper reported on the impact of grouping strategies on the economic efficiency of dairy herds (Cabrera and Kalantari, 2014). The efficiency of feed energy use was increased as the number of feeding groups increased from 1 to 4. There was little benefit to >4 feeding groups in this study. Even though GHG emissions were not estimated, they would be expected to decrease as the efficiency of feed energy use increases.
6. Nutrition and feeding management factors –
    - o. Table 2 provides an overview of some of the key factors.

Table 2. Nutrition and Feeding Management Impacts on Methane Emissions[a]

Change	**CH4/Energy Corrected Milk**
Increase dry matter intake	Decrease of 2 – 6% for each 2.2 lb. increase
Decreased forage particle size	Neutral
Processing of grain	Decrease about 1-2.5% for a 5% increase in total tract starch digestibility
Rumen pH <5.5	Decrease of 15-20%
Feeding higher grain levels	Decrease about 2% for a 1% increase in ration NFC (maximum credit about 15%)
Increased forage quality	Decreases about 5% with a 5 unit increase in total tract NDF digestibility
Fat feeding	Decreases by about 5% for each unit of fat in the ration
Forage type and selection	Decreased by 0 to 4%

7. Rumen modifiers –
    - o. There have been many papers examining the in vitro potential of compounds added to the rumen that could decrease methane production. Some of these decrease methane production by 30 – 80% but have not been evaluated in animal trials. This step is critical and especially important to examine the question of long-term efficacy. There has been a recent paper using one compound in rations for dairy cows over a 12 week period (Hristov et.al. 2015). The compound used was 3-nitrooxypropanol (3NOP). This was added at levels of 0, 1,120, 1,662 and 2,200 mg/day to a diet with 60% forage and 40% grain. Dry matter intake and milk production were not different between the diets. However, there was a reduction in methane emissions of 24.5 to 31.6% on a grams per day basis. At least over a 12 week period, there seemed to be little indication of adaptation by rumen microorganisms to this compound. This model can be used to test other compounds for potential use to lower methane emissions in dairy cattle.

WHOLE FARM FACTORS

The use of whole farm models is another tool that can be used to assess changes in farm management strategies on methane emissions and carbon footprint (Rotz, 2014). The IFSM (Integrated Farm System Model) was used to simulate the effects of varying levels of milk production and feeding strategies. Feeding strategies used were full confinement, summer grazing and an all grass, low input system. Milk production levels from 16,000 to 30,000 pounds of milk per cow were used for the full confinement system. This analysis indicated a 1% decrease in carbon footprint (lb. CO_2 equivalents/lb. milk) for each 2,000 lb. increase in milk production. A herd using summer grazing with a milk production of 20,000 lbs. had a carbon footprint similar to a confinement herd producing 26,000 lbs. of milk or more. The all grass herd with a milk production level of 16,000 lbs. of milk had a carbon footprint similar to the summer grazing and confinement herds described above. This type of approach needs to be more frequently used by the industry to examine alternative farm management approaches.

SUMMARY

The dairy industry has made great strides in lowering methane emissions and the carbon footprint of milk production. The challenge is to continue lowering the total industry carbon footprint. From a nutrition and herd management perspective, the adjustments to be made in the future can be divided into 2 basic categories. These are:

Long-Term:

- These will be applicable over the next 5 to 15 years and will require additional data and research information to provide a base for application. Examples include:
    a. Genomics and genetic selection to improve feed efficiency.
    b. Opportunities to alter the rumen microbial population.
    c. Added compounds that can alter methane emissions in the rumen.
    d. Using whole farm models to integrate crop production, manure handling systems and animal productivity.

Short-Term:

- These are technologies that can be implemented now and will help the industry to improve the efficiency of feed nutrient use and rumen fermentation. Examples include:
    a. Continue to manage animals for higher levels of productivity and improved feed efficiency.
    b. Balance rations using the new concepts of fiber and starch digestibility.
    c. Implement feeding management practices that improve consistency and minimize variability.
    c. Utilize feed additives and production technologies based on research.
    d. Select forages based on yield, quality and digestibility.
    e. Provide facilities and herd management systems that improve cow comfort and reduce stress.
    f. Improve herd health and reproductive performance.

g. Lower the age at 1st calving in replacement heifers.
h. Implement herd grouping and ration formulation strategies to improve the efficiency of nutrient use.

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